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VIDEO SIGNAL COMPRESSION

The invention relates to video signal compression.

In an important example, the invention concerns the MPEG-2 video signal compression standard, ISO/IEC 13818-2, though it can be applied to any video compression system that is liable to degradation when coding and decoding are cascaded.

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There has already been disclosed (WO-A-9535628) the use of a signal which accompanies an MPEG bitstream and which carries information about the bitstream for use in a downstream process, for example, the re-encoding of a decoded MPEG picture. This signal is provided in parallel and is sent along an appropriate side channel to accompany a decompressed signal from a compression decoder to a subsequent encoder.

Where equipment has been specifically designed for use with such a signal, considerable advantage can be gained and many of the problems previously associated with cascaded coding and decoding processes are removed or ameliorated by using in a downstream coding process, key information concerning upstream coding and decoding.

In WO-A-9803017, there are disclosed techniques which extend these advantages, in part or in whole, to arrangements which include equipment not specifically designed for use with such a signal. Specifically, these techniques include embedding the information signal in the video signal so that it can pass transparently through a video pathway.

It is an object of this invention to provide improved apparatus and processes which offer benefits not just in a cascaded recoding operation but in a primary coding operation.

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Such a primary coding operation will usually be applied to a video signal which has not previously been compressed. The possibility is included, however, of a "primary" coding operation on a video signal which has been compressed but without advantage having been taken of any of the techniques disclosed in either of the above referenced documents.

Accordingly, the present invention consists, in one aspect, in a video signal process comprising the steps of analysing a video signal and taking compression coding decisions; forming a representation of the coding decisions for passage with the video signal along a video pathway and, downstream of the video pathway, compression encoding the video signal in accordance with said coding decisions.

In another aspect, the present invention consists in compression pre-processing apparatus, comprising means for analysing a video signal and taking compression coding decisions; means for processing the coding decisions and means for outputting the processed coding decisions for passage with the video signal along a video pathway.

The coding decisions may include the following information: picture dimensions; frame rate; picture structure (frame-coded or field-coded); picture type (I, P or B): whether macroblocks are intra-coded or use prediction; whether forward, backward or bi-directional prediction is used; motion vectors; transform type; quantizer visibility weighting matrices; quantizer step; bit rate and buffer state of a downstream decoder.

Sub a4 In this description, the term information bus is used to represent information relating to a coding operation, which information accompanies a decoded signal, a partially decoded signal or a yet-to-be-coded signal. More detail can be found with reference to WO-A-9535628. The information bus is preferably embedded within a video signal for example as disclosed in W0-A-9803017. The content of both WO-A-9535628 and W0-A-9803017 is herein incorporated by reference.

Sub a5 The invention will now be described by way of example with reference to the accompanying drawings, in which:-

Figure 1 is a block diagram of a compression pre-processor according to one embodiment of this invention;

Figure 2 is a block diagram of a compression pre-processor according to a second embodiment of this invention; and

Figure 3 is a block diagram illustrating three alternative server-based processes according to this invention making use of the information provided by the pre-processor of Figure 1 or Figure 2.

Turning to Figure 1, an input video signal which has not previously been encoded is presented at input terminal 100 and passes to an MPEG2 encoder 102. This encoder takes one of the forms disclosed in WO-A-9535628 and has in addition to the MPEG output, an information bus output on which appear a representation of the coding decisions taken in the encoder. These coding decisions may include the following information: picture dimensions; frame rate; picture structure (frame-coded or field-coded); picture type (I, P or B): whether macroblocks are intra-coded or use prediction; whether forward, backward or bi-directional prediction is used; motion vectors; transform type; quantizer visibility weighting matrices; quantizer step; bit rate and buffer state of a downstream decoder.

The information bus then joins the input video signal for passage in tandem along a video pathway. It should be noted that the video signal at the output has undergone no processing, beyond delay in an appropriate compensating delay 104.

There are a variety of preferred ways in which the information bus can accompany the video signal. For example, the information bus can be carried in the least significant bit of the colour-difference part of a 10-bit ITU-R Rec. 656 signal, within the active video region only. This provides a raw bit-rate of 10.368 Mbit's for the information bus. Care will be taken to ensure that the presence of this additional information does not cause visible impairments to the video signal and that studio equipment quoted as '10 bits' is indeed transparent to all ten bits of the signal when no mixing or other processing is being performed. In other implementations, the information bus might be transported in the 9th or 8th colour-difference bit, in the 10th, 9th or 8th luminance bit or in any combination of the above. Use of the 8th bit would also be appropriate for systems using earlier versions of the Rec. 656 standard where only 8-bit representation is available.

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Another example is an extension of the above approach, in which any part of the digital video signal (not just the least significant bit) is modified by adding the information bus data to the video in such a way that a downstream MPEG coder would be unaffected.

It is also possible to carry the information bus in an ancillary data channel carried in the blanking periods of the Rec. 656 signal. It would be necessary to ensure that studio equipment passed this information unchanged when no mixing or other processing was being performed.

A still further example is to send the information bus as an AES/EBU digital audio channel. This would be passed through a spare channel in the audio path of the studio equipment. It would be necessary to ensure that switching of that particular audio channel would be performed along with the video switching, even though the main audio channel(s) might be switched independently of the video.

Figure 2 shows a more detailed configuration of a compression pre-processor according to the present invention. An information bus generator 202 receives the input video signal and generates a 'skeleton' information bus containing picture, GOP and sequence rate information relating to the input video signal, for example, picture size, aspect ratio, field/frame coding type and picture type. The video signal and the skeleton information bus are passed to a motion estimator 204. This generates candidate motion vectors which are placed on the Information Bus. A prediction selector 206 receives both the video signal and the information bus and selects between the different candidate motion vectors. It also selects which prediction mode (field, frame, forward, backward, bi-directional etc.) is to be used for each macroblock. The prediction selector 206 further performs inter/intra selection and DCT type selection.

The information bus at the output of the prediction selector 206 contains all the decisions necessary for the creation of an MPEG bitstream apart from those relating to quantization. These are provided as follows.

A "dumb" coder 208 operates on the video signal, guided by the coding decisions represented in the information bus. A bit rate controller 210 receives the coded bitstream and controls the quantization in the dumb coder to bring the output bit rate to a notional bit rate representing the probable output rate of a downstream encoder. The dumb coder then places on the information bus the quantizer information employed to generate a bitstream at the desired notional bit rate

So far, what has been described in Figure 2 is identical to an MPEG coder, based on the information bus as shown in the referenced prior publications. In this application, however, the bitstream is not used and only the final information bus appears at the output of the coder 208.

This information bus is then processed using techniques described in WO-A-9803017. Briefly, the information bus passes to an information bus coder 212 which performs variable length coding, packetisation and allocation of time stamps. This represents a convenient form of compression using, essentially, the MPEG2 syntax. Indeed, the information bus in one form can be viewed as the MPEG2 bitstream minus the DCT coefficients.

There are various possibilities for the format of an information bus signal, according to its timing relationship with the video signal it accompanies. Formatting is carried out by the information bus formatter 214. Examples of possible formats for the information bus signal are as follows:

(i) A fixed-bit-rate signal but containing a variable number of bits per picture and transmitted with no regard for synchronisation to the video signal. In practice, the signal could have a variable bit-rate but could be made to occupy a fixed-bit-rate channel by the use of stuffing bits.

ii) A fixed or variable-bit-rate signal which is re-ordered (from bitstream order to display order within the GOP structure) and time-shifted so that the information bus for each picture is co-timed with the video signal for that picture.

iii) A mixture of the two, in that the information bus itself is asynchronous but a small slot is reserved for some picture-locked data; this would carry, for example, duplicates of **time_code** and **picture_type.**

iv) A fixed-bit-rate signal which is re-ordered and time-shifted as described in the second option above, but additionally arranged so that the macro-rate information for each macroblock is co-timed with the video signal corresponding to the macroblock.

The formatted information bus then passes to a channel adapter 216, which adapts the information bus to accompany the video signal (which has been delayed in compensating delay 218) in any of the ways described by way of example with reference to Figure 1. Thus, in a preferred example, the

channel adapter 216 embeds the formatted information bus in the least significant bit of the colour-difference part of a 10-bit ITU-R Rec. 656 signal, within the active video region only.

In a modification to the arrangement illustrated in Figure 2, two or more dumb coders 208 and associated bit rate controllers 210 could work in parallel, each at a different bit rate covering the range of likely future requirements. The quantizer information generated at each bit rate could be recorded in the information bus.

In a further alternative, the bit rate controller 210 could be removed and the dumb coder or coders 208 could work with a fixed quantizer or quantizers. The resulting numbers of bits generated for each macroblock could then be recorded in the output information bus.

Figure 3 shows how a pre-processor according to this invention might be used in conjunction with a server designed for uncompressed video signals. The pre-processor works as described above to add an information bus to a digital video signal. The resulting video + information bus signal is written onto a server. There are then shown three examples of how the signal might be used downstream to produce bitstreams.

In each example, the signal is read from the server and sent to an Information Stream decoder which passes the resulting video and Information Bus signals to a dumb coder.

In the first example, dumb coder 1 simply slaves to the incoming video and information bus signals and produces a bitstream at the bit rate (or a chosen one of the bit rates) generated by the pre-processor.

In the second example, dumb coder 2 works at a new bit rate. The quantizer information in the information bus is ignored and is replaced by quantizer information calculated by the local bit rate controller.

In the third example, (enhanced) dumb coder 3 makes use of both the local bit-rate controller and the quantizer or bit-count information decoded from the information bus to improve the performance of the encoder. Effectively, the known benefit of two-pass encoding is obtained, that is to say pre-analysis and a second pass through the bit rate control process.

Either of the second two configurations could be used as part of a bitstream switch or other bitstream processor in which it is necessary to control the bit rate and the occupancy of the coder buffer.

Whilst the use of an information bus which is effectively the MPEG stream minus the DCT coefficients, is extremely convenient, other options exist for representing the coding decisions. A range of formats could be employed and various compression techniques employed. In addition to the coding decisions, useful statistical information from the coding process can also be carried.

Note that the present invention is not confined to MPEG2 compression. It could be used with a wide variety of compression technique, or even with mixtures of techniques, although in this case the processing of the decoded information bus would be significantly more complicated, as it would involve the re-interpretation of coding mode information for a different compression scheme.

It should be understood that this invention has been described by way of examples only and a variety of further modifications are possible without departing from the scope of the invention.